THERMAL MODELING OF LI-ION CELLS

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Introduction

Previously, a thermal-electrochemical coupled model was developed to describe the operation of a Li-ion cell.[1] The model was used to study various design criteria (aspect ratio of cells, rate e.t.c) and the importance of coupling the thermal and electrochemical properties was pointed out. This combined approach was found to provide considerable insight into cell operation. Figure 1 illustrates one such prediction of the model, where the cell temperature and reaction current distribution at 75 % DOD during a 3C discharge is illustrated. The large difference in temperature (40°) within the cell and the effect of this difference in the electrochemical behavior is clearly seen.

This model has been made more comprehensive with the incorporation of the reversible heat effects, in addition to the previously described joule and irreversible heat. Experimental entropy measurements on manganese spinel[2] and carbon were used for this purpose. In addition, the film resistance and the ensuing heat generation due to ohmic losses have also been included. Figure 2 plots the heat generation rate during 1 C discharge of a cell, where the importance of the two phenomenon are clearly seen. The importance of the entropic contribution is further exemplified in Figure 3, which plots the contribution of each effect to the total heat generated in the cell. Such plots provide an ideal means of comparing the model to experimental calorimetric data.

The talk will provide an overview of the capabilities of the model in describing the thermal behavior of Li-ion cells. The emphasis will be on understanding the underlying phenomenon during operation. Case studies will be shown that illustrate the importance of cooling, especially for cells in a stack. The SOC imbalance between the different cells in the stack, which such a thermal excursion can lead to, will be explored. The effect of these imbalances and the methodologies for addressing them will also be pointed out.

References

1. W. B. Gu and C- Y. Wang, *Lithium Batteries*. R. A. Marsh *et. al.*, Eds., PV 99-25, p. 748, The Electrochemical Society Proceedings Series, Pennington, NJ (1999)
2. K. E. Thomas and J. Newman, Intercalation Compounds for Battery Materials, G. A. Nazri, *et. al.*, Eds, PV 99-24, The Electrochemical Society Proceedings Series, Pennington, NJ (1999).

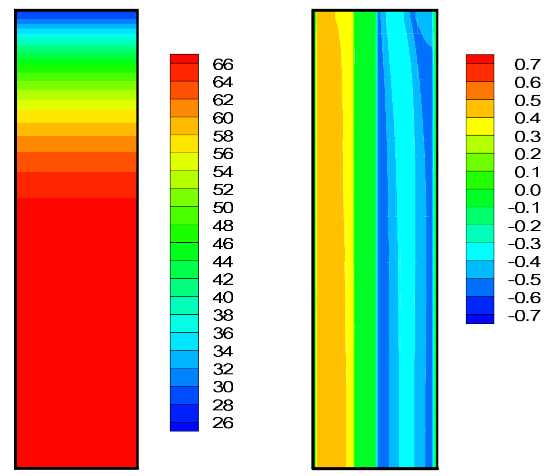

Figure 1. Simulated temperature (left) and reaction current (right) contours generated during a 3 C discharge of a Li-ion cell. Heat is dissipated only from the tabs, located on the top. Cell width=0.042 cm; height=50 cm.

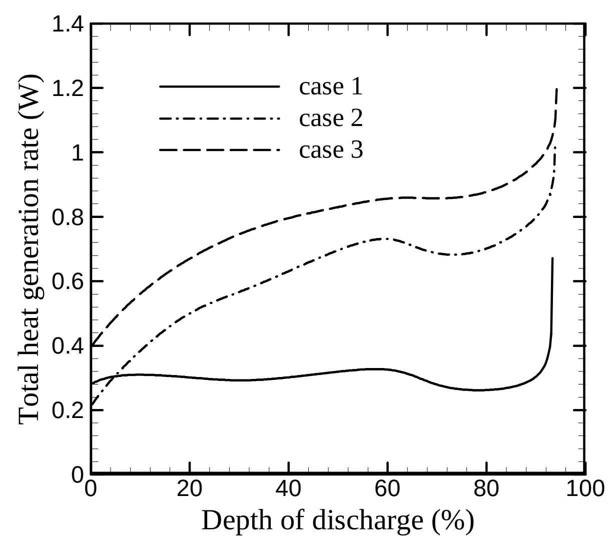

Figure 2. Heat generation rate during 1 C discharge of a Li-ion cell under adiabatic conditions. Case 1: No reversible heat and film resistance; case 2: reversible heat included; case 3: film resistance included.

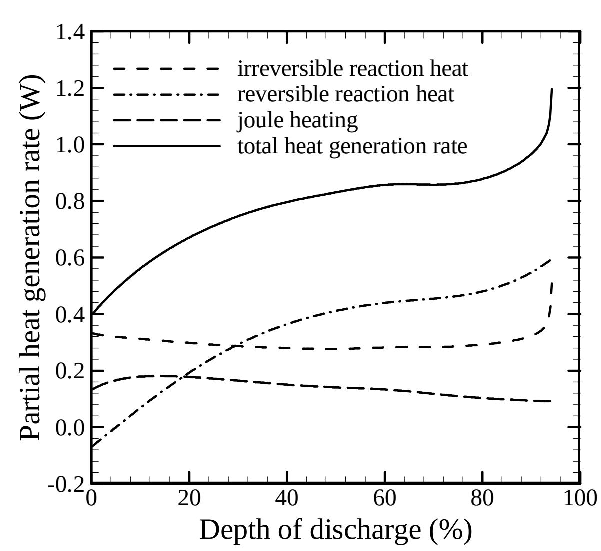

Figure 3. Partial heat generation rates during 1 C discharge of a Li-ion cell. The plot shows the contributions of the each effect to the total heat generation.